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Video Technology to Advance Safety in the Operating Room and Perioperative Environment

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Video is a powerful medium and is underused for patient safety in several areas: education, real-time consultation, process improvement, research, and workflow coordination. We illustrate this point through an overview of uses of video in health care by the authors and others in several institutions. These uses were in the context of team work training, operating room coordination, technical skills of invasive procedures, process improvement, telementoring, and multimedia video records. Also described are several key issues associated with the use of video, such as ethics and legal concerns. Technology advances and new methods will make video an important tool for improving patient safety.

Keywords: critical incidents; team performance; surgical workflow; ergonomics; video technology

Introduction

The patient safety movement received national attention by the publication of the Institute of Medicine 1999 report on human errors in medicine.[1] According to the report, up to 100,000 people die each year in American hospitals as a result of preventable medical errors. Certainly no health care professional comes to work in the morning expecting to cause harm, but even with the best of education and training, humans will be human and make errors. The report highlighted a basic premise of safety: humans will make errors, but safety can be improved through cultural and systems changes. Systematic investment in research and in performance improvement is needed to achieve sustained gains in safety. Reduction of medication related errors, for example, was recently reported through the use of computerized order entry systems.[2] In the 1999 Institute of Medicine report, although medication errors were singled out as the leading cause of preventable errors, surgical errors were listed as the second leading area of patient safety concerns. The report cited that nearly half of surgical complications were attributable to errors.[3]

Nontechnology Approaches to Patient Safety

In order to develop an effective and efficient approach to improving patient safety, certain aspects of the hospital environment must come into alignment. First, the CEO and hospital board must commit to the safety agenda and with it the requisite resources of time, people, and money. Preferably, specific actions should be entered into the hospital operational plan so that the safety program is afforded clear recognition and guidance and a change occurs in the usual culture of blame. Hospitals in general have tended toward a punitive attitude toward mistakes. This only reduces the opportunity to learn where the real problems lie. It should be both acceptable and expected to admit to and to identify and report errors and "near misses." The errors can then be

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studied with root cause analyses to determine the most appropriate system changes that will assist staff to either not repeat the error or detect it before it can cause patient harm. The results of the root-cause analyses feedback to the staff are used to make the needed changes to hospital processes, facilities, and equipment. Another important culture change is prompt, full disclosure to patients or their family of errors.

Human factors critical to patient safety that should be addressed include leadership, management of the operating room (OR) suite, teamwork in the OR, OR communication, information transfer, and training. One effective approach is the concept of "crew resource management" (CRM) training as developed by the airlines[4] and now being tentatively extended into the OR.[5,6] The key elements of CRM are briefings, communication, assertion, cross-checking, verification, and decision making. Each of these is an aspect of teamwork that can be improved with appropriate training and practice and combined with teamwork training that emphasizes conflict resolution and collaborative problem solving.

Technology Approach to Patient Safety

In addition to cultural changes and training, technology can play a leading role in improving safety. We report here on how video can be used in numerous ways to reduce errors and near misses in the OR and its environment. Importantly, the technology of video is combined with critical human factors analyses that are essential to effectiveness when using any technology.

Video technology, for example, can be used in a number of ways to support improvements in patient safety in the OR.

Video can capture team performance, document technical skills, and be used to analyze systems factors.

Video as a rich medium allows systematic and repeated examination of factors impacting on patient care, including instrument setup, patient monitors, sterile practices, operator postures, procedures, and interpersonal interactions.

A camera built in the OR light source allows the anesthesiologist and scrub technician/nurse a much improved view of what is going on in the operative field; as a result, they can anticipate and coordinate their activities better with the surgical team members.

Through video, a surgeon can call a colleague to look in on a difficult procedure without the need for traveling to the OR and "scrubbing in."

Video of OR activities can assist the medical and nursing management teams to use the ORs in a suite, that is, "command and control function" for video. Similarly, a video white board allows rapid situational awareness about what is happening in any OR.

Video information on the condition of a patient after surgery can be sent remotely to be viewed by a surgeon or anesthesiologist in the OR who wishes to see the patient's status if there is a problem.

Video can augment the training of residents and medical students as it allows them to be in a distant conference room with an instructor rather than in the "third row" in the OR where they cannot see clearly the training event.

Video of a procedure or case can allow an "after-action" review of technique, identifying both problems and solutions that may not have previously been appreciated.

Video record of an entire surgical or medical procedure could be incorporated with the electronic medical record and voice-activated operative note dictation to allow in-depth review after the procedure is completed. By analogy, every Monday, each NFL team critically studies the videos of yesterday's game to detect errors and plan improvements.

The OR of the future should be a safe, efficient, learning environment for all care providers and supporting workers. Leveraging and harnessing new computing and communication technology can be a powerful approach to that goal. Previous and ongoing studies have demonstrated that administration in and around the OR is a complicated, complex, and often chaotic process.[7] Technology can and should play a significant role in making the OR of the future safe and efficient, as demonstrated by recent technology experiments.[8,9]

Video for Learning and Teaching

Video has been used since its first consumer adoption for the purpose of learning and teaching. Ubiquitous uses of video to improve patient safety in the OR are more feasible today than ever before because of improvements, miniaturization, and reduced costs of the video technology. Applications from clinical settings other than the OR can provide a guide to the use of video.

Use of Video for Teamwork Skills Training

Video footage of medical teams at work can serve as a valuable source for team training. For example, Aptima, Inc. developed a program in conjunction with researchers at the University of Maryland Shock Trauma Center for training teamwork skills in emergency medical teams.[10,11] In the program, video segments taken in the trauma resuscitation unit at the Shock Trauma Center were used for illustrating good and poor examples of teamwork skills and as the basis for teamwork skills training exercises. In these scenario-based training exercises, trainees are asked to identify instances of ineffective teamwork that occur in the videos, specify the teamwork skills that were lacking, and discuss how the shortcomings identified could be addressed during a debriefing or conduct a mock debriefing based on their analysis of the video clip that was presented. In contrast to other teamwork skills-training programs, such as those based on CRM principles (e.g., Gaba et al[6]) in which the trainees themselves participate in a training scenario, the use of video allows for synchronous and asynchronous standardized training across multiple teams, as the same stimulus materials are used. In addition, the debriefing exercise allows trainees to discuss examples of teamwork that are germane, but in which they have not clinically participated, thereby alleviating any tendency to be defensive.

Just-in-Time Video Guide

A lack of familiarity and training could be a barrier to fluent performance. Textual descriptions and static pictures limit the effectiveness of describing how to carry out complicated procedures, such as preparing the OR for a surgical procedure. An assistant may be unfamiliar with a particular surgical procedure or the approach of a particular surgeon. Watching a video recorded OR setup first may avoid mistakes in actual practice. Because perceptual cues and psychomotor maneuvers used in many procedures are often complex and dynamic, it is especially important to provide guidance about these cues. One project at the University of Maryland, sponsored by NASA, is examining design principles of how to provide "just-in-time" video guidance to support astronauts in medical emergency procedures, where guidance is provided at the time of need. Video-enhanced guides may be more useful than text descriptions and more practical when domain specific issues (e.g., microgravity) make page turning difficult.

Video for Teaching Best Practices

Frequently, trainees or even experienced staff may not be aware of best practices or may not realize the consequences of not following best practices. Two projects carried out at the University of Maryland demonstrated that short, informative video clips can overcome both of these barriers to complying to best practices. In one project, the best practice for chest tube insertion was established through expert consensus, and a training course was developed that resulted in decreased complication rates.[12] The course contained both positive and nonideal video examples from real patient care. In another project, best practices to prevent central line–associated blood stream infection were taught to trainees, using short, high-impact video examples from real patient care. In both projects, compliance to best practices was improved, especially in the area of sterile techniques. Although analysis is not finished, preliminary analysis of compliance data suggested that use of video was shown to be more effective than paper or didactic training in reducing breaks in sterile technique.

Video for Research and for Patient Safety

Process improvement is the basic method to improve safety and quality in any medical practice setting. Video-based research can augment the ability to discover the needed process improvements. We have divided these approaches into three opportunities for improvement.

Potential Uses of Perioperative Video

Video data have many applications in the medical domain, including use for research data collection, in support of quality-improvement initiatives. Video can be used to study various types of perioperative patient risks such as the following.

Patient identification requires that the right patient is in the OR, the team knows all of the patient's medical issues (heart or respiratory disease, allergies, etc.) and data (laboratory, imaging, etc.) in addition to knowing the planned site of the operation (left breast, not right), and the procedure to be carried out (lumpectomy with sentinel node removal,

not mastectomy with axillary dissection). Furthermore, the entire team needs to know what the plan of work is to be, including contingencies if something unexpected is found, so that each team member can do his or her part effectively. All of these significant issues in many OR suites can be captured by audio–video recording of standard operating procedures for a given surgical procedure. Analysis of these recordings can identify the improvements needed in communications or procedures in patient identification. Because data about the patient are scattered over many systems, there is a culture of inadequate team communication in the OR.[5,6] Interventions to improve team *communication* (e.g., briefing before surgery starts) can be evaluated through video-based methods to capture the efficacy of this approach and breakdowns in teamwork.[13]

Medication safety in the OR is a high priority just as elsewhere in the hospital but amplified by the fact that in the OR the patient is anesthetized and is unable to communicate with care providers.[14] The OR is a place where fluids of various types are used to irrigate the site, clean the skin, etc., but these are often made up in the individual OR, placed on the side table but not labeled—an error waiting to happen. Video could record confusions and evaluate the impact of better labeling.

Infection control is critical in the OR environment. Prophylactic antibiotics are a key issue in OR safety in that the right drug needs to be given at the proper time at the start of the case if infection is to be avoided. The culture is such that no one would enter the OR without properly scrubbing and gowning, but there much is less attention paid to the administration and timing of prophylactic antibiotics, the use of the correct (chlorhexidine) skin preparation, monitoring blood sugar of diabetics undergoing cardiac surgery, or full gowning and draping for insertion of vascular catheters. For example, video can be used to improve gowning techniques through video feedback.[15]

There are a host of critical *intraoperative factors* that relate to safety, including patient positioning, electrical equipment, fire safety, laser safety, endomechanical devices, monitoring of critical variables, imaging safety and the best practice protocols of needle, instrument sponge counts, and universal precautions. Video can be a comprehensive medium to capture factors that potentially reduce margins of safety.[16]

The *OR environment* creates its own set of potentials to foster errors. The staff is rather insular. Nurses and technicians come to work, put on scrub outfits, and remain in the OR suite for the entire day. They eat lunch there, take their breaks there, and socialize there without leaving until their shift is over. Because it requires donning scrubs to enter, few personnel from elsewhere in the hospital visit the OR. The OR staff is thus less likely to be aware of changes occurring in other units of the hospital and is less likely to embrace change. The OR today is very technology driven, and thus, the staff must be familiar with many new pieces of equipment. Greater sophistication of equipment means increased cognitive burden on the OR staff and more opportunity for error. The OR today is productivity driven. It is important in today's hospital financial climate that these capital-intensive suites are maximized and made as efficient as possible, but this also creates opportunity for error. By combining a high velocity, high complexity, and tense environment with a strong hierarchy, the makings for error generation are apparent. Use of video in process improvement projects is a natural choice to allow others to study OR work flow and to understand safety issues inside the OR.

In all of these settings, video-based research can help to define the issues and areas of greatest problematic concern. For example, is the OR team adequately using the Joint Commission on Accreditation of Healthcare Organizations–mandated "time out" process to fully yet succinctly brief each other on the issues relevant to the patient and the patient's intended surgery. Has there been discussion of the patient's cardiorespiratory decompensation during a previous surgery? What about antibiotic allergy that will affect the use of prophylaxis? The site and procedure planned and contingencies for unexpected findings? Just as every NFL team reviews the video of its last game on Monday morning, so too the surgical team can review the video of its work after the case has been completed. After the problems in the process are fully appreciated as a result of the video review of the briefing, the team can develop the necessary changes to these processes so as to improve patient care and safety.

Video Used for Studying Intraoperative Team Performance

Multiple cameras in the OR may be needed to capture team performance. Such video records should be reviewed to understand team performance comprehensively and to evaluate the impact of a preprocedure briefing tool (a checklist) on team performance during laparoscopic cholecystectomy.[13,17] Audio–visual

data collection was found to add to the quality of the results in several ways; it allowed the researchers to hear participants better through the use of headsets and to re-review events where there was a discrepancy or missed data collection during the case.

Guerlain et al developed a training course based on the video clips from some of the laparoscopic videos recorded.[18] The training course was designed to help medical students develop perceptual judgment skills required for laparoscopic surgery (e.g., recognition of critical anatomy and dissection planes) before entry into the OR. The training modules used video clips from actual surgeries to show multiple examples of key successive steps in the surgical procedure. Each clip was composed of multiple video images from different cases edited together to create a repetitive submodule for each surgical step.

Mackenzie et al used videotaped performance during airway management to study team performance and decision errors. Airway management is frequently carried out under emergency circumstances. Flawless performance is important. Through detailed analysis made possible with video recordings, several team performance failure modes were identified, such as lack of communication, fixation errors, and poor workplace layout.[19,20] Assisted with head-mounted video cameras, video-based methods could be used to study the impact of workplace layout on performance in detail. Seagull et al, for example, identified "awkwardness" of workplaces based on such videos by examining the dispersion of attention and physical activity spans.[21] Such dispersion has been a challenge to anesthesiologists, as monitoring equipment and devices are scattered around them, often directly behind them, making continuous monitoring ergonomically difficult.

Video Used for Surveillance of Rare Events and Detailed Performance Measures

Despite the unacceptably high number of adverse events in healthcare, the overwhelming majority of surgical procedures are performed at high standards. This can make further improvement of safety and quality very difficult, as adverse events are rare and difficult to capture, especially those with severe untoward patient outcomes. Continuous use of video recordings can provide a form of surveillance and allow retrospective review of only those cases with extreme or unexpected outcomes, as demonstrated by Weinger et al.[22] An early example of using video was a program lasting over 3 years in initial resuscitation of trauma patients.[23] The program videotaped every resuscitation, which was reviewed by the staff and by the individuals involved. In a weekly review conference, footage was presented to the team and critiqued, and didactic information was presented. Video recording allows analysis of priorities, cognitive integration, physical integration, time, errors or breaks in technique, and behavior change over time. Weekly review contributed to improved technique and trauma care. Over a 3-month period, average time to definitive care decreased. Resuscitations became more efficient and adherence to assigned responsibilities better.

Video for OR Command and Control

Delays in OR case starts are a major frustration to clinicians, patients, and families. The OR team is a significant cost center for any medical institution. Efficient use of the resources and OR team members is imperative. OR clinical personnel are among the busiest in a hospital, with time critical procedures to be performed. Improved situational awareness by remote video access to the OR may improve team performance by minimizing lost time. Provision of visual access to the OR from a "distant location" will allow novel use of video in the OR of the future.

The central coordination challenge in such a chaotic and dynamic setting as the OR is situation awareness: the ability to see what is happening (perception), to appreciate the significance of changing situations (comprehension), and to anticipate future situations (projection). Video captures evolving situations, yet it is passive: no human input is necessary to update and maintain the display of current status. Feeding video from appropriate sources to needed care providers can potentially improve situation awareness and coordination efficiency. Studies of the use of video to improve situation awareness in air traffic control, for example, have demonstrated the strength of video.[24]

Communal User Interface: Hybrid, Tangible Large Displays

Although many OR suites use closed-circuit television systems to help coordination, effective use of video relies on a staff's ability to integrate real-time information from video with other information sources, such as surgical schedules and staffing patterns. Because of the dynamic nature of surgical schedules,

many OR suites use white boards to allow staff to annotate and represent case assignment and changes. White boards have the benefit of easy user interface and reliability and provide a means for collaborative management: multiple people can change and update white boards. One project at the University of Maryland experimented with a hybrid interface based on physical white boards. Video images and OR occupancy data are projected on OR white boards. Staff near the white board can see (in real time) the status of activity in the OR: For example, is the room cleaned and equipped? Is the patient present? Are all of the needed staff members in place? The chief of surgery at University of Maryland commented that he uses the system to review the status of all of his ORs multiple times per day with just a few glances without the need to enter each OR. This improves his decision making regarding disposition of rooms, staff, and patient's in need of urgent surgery. Such user-friendly interfaces make data integration easier.[9] This project also investigated passive data-acquisition methods, such as automatically detecting patient in and out of ORs.[25]

Intraoperative Use of Video for Coordination

Surgery is a collaborative activity supported by a shared mental model of the surgical plan, knowledge of tactical approaches, patient condition, close cross-monitoring, and seamless integration of cognitive and psychomotor inputs. The surgical team members continually share assessment of the situation, which can change dynamically with direct implication to patient safety and success of the surgical objectives. In academic medical settings, procedures tend to be novel and nonroutine and often involve physicians in medical training. The ability to share information in such settings is critical.

There are a number of obstacles for team members in an OR to share information. In "open" procedures, where surgical wounds are open (which consist of about 80% of all surgical cases), often the operating surgeon has the best view, but it is unavailable to other team members. Communicating verbally may not be the most efficient and effective way to share information. In the common teaching situation in which an attending surgeon assists a resident surgeon, it is imperative for the attending surgeon to have real-time knowledge of the situation; however, the attending surgeon's view is often restricted and compromised, sometime during most critical moments of a procedure.

Video can be used to display the operating surgeon's view, allowing all team members to have access to the best view. Furthermore, heads-up displays can be worn by the attending surgeon to visualize better the surgical field without turning away from his or her direct view. Overlay of the operating surgeon's eye-gaze information on top of video images of surgical fields can provide information on where the surgeon is looking, without the need for verbalization. One can imagine that telemarkers are used on video images to assist verbal communications. For example, references to the patient's anatomy may be indicated by telemarkers (e.g., "here"), or the direction of activities may be similarly indicated (e.g., "in this way"). These technologies, in their different implementation context, have demonstrated great utilities.[26]

The use of intraoperative video may improve the learning experience of surgical team members during open surgery, improve coordination among the team members during surgery, and improve the ability of team members to communicate effectively and to have shared situation awareness.

Teleconsulting Use of Video

"A picture is worth ten thousand words." Dr. Bruce Jarrell, at the time chair of surgery at the University of Maryland Medical School and surgeon in chief at the University of Maryland Medical Center, arrived for an 8 a.m. meeting noting that he had been concerned that he would be late. He explained that about midnight a surgical acquaintance had called him from a town 60 miles away. He was in the OR with a patient who had some serious bleeding that he could not control. He hoped that Dr. Jarrell could give him advice over the phone. After listening intently, Jarrell decided that he could just not grasp the problem without seeing it; audio was not sufficient. He dressed, drove the 60 miles to the distant town, scrubbed in, and was quickly able to suggest the correct approach. He concluded from this experience that video was critical for situation awareness and when called about the Army's planned program around the OR of the future confirmed that video was critical for situational awareness.

Through information and communication technology, telemedicine has opened ORs to enable interaction with trainees and consultants. The real-time interactivity achieved through telemedicine over great distances provides great potential to decouple the location of expertise and that of need.[27,28] Video is an essential medium among other data elements.

Issues With Using Video

Video Acquisition

Video records can be used for multiple purposes, and thus, it is important to know what aspects of the situation are to be captured and bring to bear the necessary technology to do that. For example, if video records are used for teamwork training, as in the distributed training program Entin et al developed,[10] then it is critical that the staff members' communications and their interactions with each other are captured. Intense focus on technical aspects of the surgical procedure may be less important in that training milieu. On the other hand, if the video records are used to help train surgeons in operative procedures, as for example by Guerlain et al,[13] capture of the larger OR situation may be less critical. The video-acquisition technology must be set up in a way that the critical aspects of the situation are clearly captured. When video acquisition has multiple potential purposes, such as training, quality management, human factors, and ergonomics analyses, then multiple image acquisition is helpful. Capture of images of the care providers interacting with the patient, the patient's anatomy, and video screens used to monitor vital signs or make diagnoses (e.g., colonoscopy images, ultrasound scans) or perform surgery (e.g. laparoscopy, telerobotic images) gives a comprehensive picture of events useful for multiple future analyses. Although the OR is an obvious medical venue for capture of images, surgical fields are especially difficult to describe and document accurately with video. Currently, despite the technology to allow such video applications, integration of full-event capture as part of the OR routine has not become a standard, even for laparoscopy, where the image is readily available for storage, review, and transmission. The Medical Informatics and Technology Applications Consortium has progressively addressed the matter for some years. Organization of video information for review and transmission in laparoscopy was first approached for remote mobile surgical practice,[29 30] and the technology for capture of open procedures was accomplished with camera fixation and data compression to accommodate low band-width realities in remote areas in 2002.[31,32] The use of simple cameras, image data compression, and Internet connectivity has made it possible to share the OR environment for both laparoscopic and open surgery on a routine basis. The Medical Informatics and Technology Applications Consortium group has transmitted detailed OR procedures in small surgical fields for sharing in collaborations with Romania and Russia as well as Ecuador. High-quality capture and storage for review were refined for thyroidectomy in 2003[33] and for transmission in 2004.[34] Incorporation of the perioperative material into a continuum that included intraoperative video was reported in early 2005.[35] Current work with software to collect, store, and invite prompt review was reported later in 2005.[36] The standard laparoscopic cameras are placed near the surgical field, and the software is operated by foot pedals to record the image using a master camera and multiple camera angles. Voice recognition and transcription are done by the surgeon using foot pedals to navigate the software to annotate events as they occur. Review of an event for root cause analysis allows rapid review of gigabits of information along the operative timeline. For example, 21 critical parameters with regard to patient outcome can be reviewed and summarized in about 20 minutes (personal communication with Dr. Merrell). Future work will move beyond root cause analysis and merge previous work with transmission to support synchronous intraoperative consultation with full access to the many video, anesthetic, and audio events relevant to an intraoperative event plus the preoperative images and text to permit comprehensive and timely consultation.

Video Archiving, Indexing, and Accessing

Another key research issue concerns the archiving and indexing of video records. After the appropriate technology is in place, it is straightforward to capture a large number of incidents on video. Xiao, Mackenzie, and their colleagues at the University of Maryland Shock Trauma Center have a large inventory of cases stored on video.[16] The challenge is in accessing those cases for differing purposes. To do this, a categorization schema for indexing must be developed, and this schema must incorporate the varying purposes for which the video may be used. For example, when video is used for teamwork training, the training developers might want to find both positive and negative examples of the components of teamwork, such as communication, backup behavior, or leadership without having to review a huge volume of video-recorded cases. On the other hand, if video records are used for procedural training, the developers look for optimal and nonoptimal performance of a particular procedural technique. For example, identification of the cystic duct during all video-recorded laparoscopic cholecystectomies may be indexed to

show trainees the anatomic variations across patients and difficulties in this crucial step. The development of an indexing schema that is meaningful and sufficient for any category of training is in itself a challenge. Developing a taxonomy that can allow video to be used for a variety of purposes is an even more daunting task, but one that is necessary if the resource is to be effectively used.

Ethical and Legal Concerns

To obtain staff buy-in for video recording, it is critical that staff members are assured that the video will not be used for punitive purposes and that it can and will be used for constructive purposes. Limiting view angles, restricting duration, targeting activities, judicial use of audio recording are some of the tactics for gaining staff support for video recording that can reduce medicolegal concerns. Digital video may be processed to strip or block potentially sensitive images (e.g., faces). Developing a restrictive protocol first may be a way to gain trust and support from staff while they develop familiarity with video recordings. It may be necessary to conduct regular meetings with staff and to establish policies to prevent the use of video recordings in job actions or performance reviews.

For research projects, protocols that include video recording must be approved by the institutional review board for human subjects of research. By its nature, research limits the scope of video recordings. Patient consent may be waived under special circumstances, such as during emergency procedures. Images with identifying information about the patient can usually be safely removed without jeopardizing research objectives. When research is targeted to key procedures, it is possible to extract short clips (e.g., 2 to 3 minutes) and to destroy the rest of recordings. Video is a very powerful medium. A concern is that, even when researchers obtain a subject's consent, it is not always clear that the subject understands the implications of that consent. Subjects should be provided with the option of reviewing their own video recordings afterward and the option of destroying the video after the fact. Fewer research subject participants are needed than might be thought to obtain video data. For example, in one project, over 100 video recordings were made with just six research subjects.[16]

Video Review and Analysis

Given that there are many facets of interest in any given video record, it is difficult to analyze efficiently all, or even a significant portion, of the recorded events. One way that enables aggregation and at the same time increases efficiency in video analysis is through the development of a "best practice" template (e.g., advanced trauma life support). Multiple video records of similar procedures (e.g., trauma patient resuscitation) can be reviewed in comparison to such best practices. Extraction of quantitative performance metrics from multiple video records of the same process is an efficient way to obtain easily useable data from video records, although this does not suit all situations. Over the course of recording numerous cases, some stand out with unique or interesting characteristics.[16] The best practice template-based analysis may not capture these characteristics. Critical incident analysis, although an interview technique originally developed by Flanagan,[37] represents a data analysis method that focus on individual episodes. These episodes often reflect interesting strategies, team performance patterns, and cognitive errors.

With comprehensive data gathering (e.g., including audio–video recordings, system logs, retrospective reviews by participant subject matter experts), one can potentially reconstruct these episodes in great detail. Examples from our critical incident analysis include those on fixation errors,[38] communication errors,[19] and team coordination.[39]

Video Analysis Tools

Tools are needed to analyze video data effectively. Desirably, these tools should allow basic annotation and event marking/searching. Additionally, tools capable of random access to data, concurrent viewing of multiple time-line documents, touch coding, assisting iterative/recursive categorization would certainly help. Document management (patient records, questionnaires, review annotations, coding results, transcripts, patient physiological data, case logs) make video analysis more productive as data are obtained from many different sources. A key advantage of studying real-life performance is the access to subject matter experts. There four basic elements to video data analysis: (1) data gathering, (2) video review, (3) development of measurement tools, and (4) interpretation of data. One should anticipate an enormous amount of effort from subject matter experts. To achieve these four elements, a core group of subject matter experts is essential.

Commercial packages are available for the Microsoft Windows platform. Some of them allow

structured coding to capture multiple aspects of video data, such as activities, postures, movements, positions, facial expressions, social interactions, or any other aspect of human or animal behavior. Several researchers developed their own video analysis tools to meet their unique demands. Guerlain et al (2004) developed RAVE, a system to view multiple video sources from different cameras in a synchronous manner for the investigation of performance during laparoscopic procedures. Weigner et al (2003) also developed their own video capturing and analysis tool for studying nonroutine events during anesthesia.

Summary

Video is a power medium and is underused for patient safety in several areas: education, real-time consultation, process improvement, research, and workflow coordination. Technology advances and new methods will make video an important tool for improving patient safety.

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